Alien Populations EXPLODE!

Subject: Life science, Math

Grade: 6-8

Lesson Topic: Impact of seed production

Length: 1+

Learner Objective:

Students will learn that the impact of weeds begins with large seed production.

Students will be able to calculate and graph the exponential growth of seed production over time.

Students will be able to discuss the variety of environmental factors affecting germination.

Introduction:

In this session students will explore the seed production capabilities of various invasive weed species and the potential barriers that can inhibit population explosions. With a background in math (percentages and graphing) the activity will illustrate the *exponential* explosion of invasive plant populations.

Content:

In previous activities the students have learned about some of the adaptations of invasive weed species that enable the plants to be so successful in habitats outside of their native range. One of those adaptations is a prolific number of seeds, but what is really meant by that? We know that a common evolutionary precept is that nearly all species produce offspring in greater numbers than can survive. When it comes to alien plants, how many seeds are we really talking about and how many of those seeds actually will germinate and survive to become mature plants? Without barriers to the survival of great numbers of offspring, the numbers of a population will exhibit *exponential growth*, in other words, the numbers will increase at a steady and unusually rapid pace. Many of us have heard of the examples used with the number of cats or rabbits that one pair can produce in a year, but these "statistics" are frequently touted as problematic without a discussion of the natural or human barriers that prevent such occurrences of explosive population growth. In this lesson the students will utilize current research on certain invasive plants which seek to address the various barriers and environmental factors which determine population growth. The students will see that invasive plants, unlike cats or rabbits, exhibit phenomenal growth potential even when factoring in germination rates, seedling survival rates and other barriers such as temperature, moisture, and competition. The lesson leads naturally to other barriers that may inhibit population explosions, especially those barriers that humans may impose to prevent *Aliens In Your Neighborhood*.

Materials and Supplies:

Chart of Seed Production and Germination – Teacher's Version

Chart of Seed Production and Germination – Student Version (chart only with space to take notes)

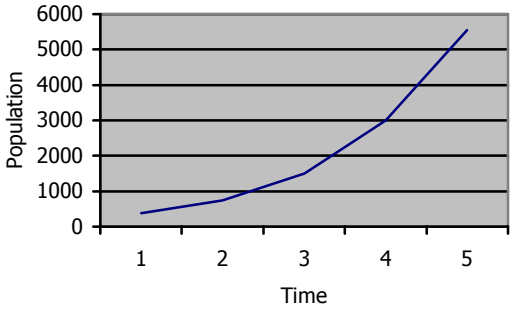
Seed Production Calculation Sheet

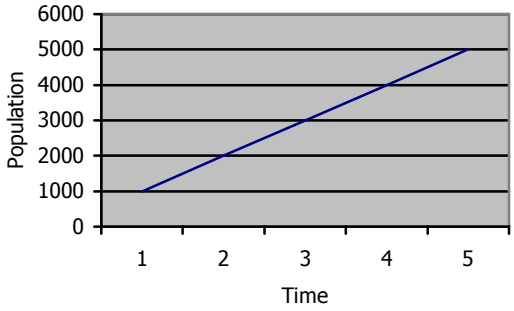
Graph paper

Calculators

Anticipatory Set:

Show students the two following graphs and ask them to explain their understanding of the two curves. The first graph is typical of populations growth without barriers (though they will soon learn that even with some barriers at play certain species like invasive weeds can still exhibit this exponential growth pattern).





Activity Outline:

Display an overhead transparency of the Chart of Seed Production and Germination and provide the students with their own copies so that they make take notes as needed. Ask the students if they can make any sense of the numbers represented for each species. The numbers are a reflection of some of the natural barriers to population growth and other factors. For example, the Canada thistle relies heavily on pollination from bees in addition to season temperature and humidity factors. There must also be good numbers of male and female plants in close proximity. If all conditions are not met it is possible to have no seeds produced. A plant like cheatgrass, with high germination and seedling survival rates, shows high adaptability in a wide range of environmental conditions. Notes are provided below the Teacher's Version of the chart to aid in this discussion

Provide the students with the Seed Production Calculation Sheet. From the Chart of Seed Production they should choose a plant species and record the data for that plant on their worksheet. Where a range of numbers or percentages is given, students may use the higher number, and average, or any number within the range… the important thing for them to understand is that seed production, germination rates and survival will fluctuate widely depending upon the state where the plants are found, the habitats it has invaded, seasonal weather patterns, soil and nutrient conditions,

temperature and humidity, depth of seed in the soil, competition, and many other localized factors.

Have them fill in the appropriate blanks with the data they have chosen, and using their calculators, determine the numbers of seeds, seedlings and mature plants for a three year time period. They should transfer the data to the chart provided. The data chart is a good "stopping point" if you run out of time or need to help slower students. The questions following the data collection can be answered by the students in class, as homework, or in class discussions. Once the data is calculated and charted the students should proceed to the graphing portion of the activity. Students may create their own graphs (with colors!) rather than the one provided in this lesson. Advanced students could go on and pick another species to run the population calculations, and then graph that plant as a different color, overlaying their first set of data.

Closure and Assessment:

Collect and evaluate student worksheets.

Create rubric to score class involvement, discussion, ability to complete task, and reliance or mentoring of peers.

Independent Practice and Related Activities: (I combined mine with Ag's because they are different but important extensions)

Resources:

U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2003, June). Fire Effects Information System (FEIS), [Online]. Available: http://www.fs.fed.us/database/feis/ [July 7, 2003]

U.S. Department of Agriculture, National Plant Data Center [Online] http://plants.usda.gov/ [July 8, 2003]

Credits:

Lesson adapted from Return of the Natives (RON), a Curriculum and Online Toolbox For The Restoration Of Native Plants & Eradication Of Invasive Weeds [Online], http://watershed.csumb.edu/ron/roncor/cor/index.htm [July 8, 2003] which adapted a similar lesson from:

The Montana Weed Trust Fund Teacher's Handbook and "What's Wrong With This Picture? Invasive Weeds: A Growing Pain", BLM, from the Montana War On weeds [Online] http://mtwow.org/ [July 8, 2003]

Vocabulary:

Allelopathic, annual, exponential growth, perennial

National Science Education Standards:

Science as Inquiry - CONTENT STANDARD A:
As a result of activities in grades 5-8, all students should develop

- ❑ Abilities necessary to do scientific inquiry
- ❑ Understandings about scientific inquiry

Life Science - CONTENT STANDARD C:
As a result of their activities in grades 5-8, all students should develop understanding of

- ❑ Structure and function in living systems
- ❑ Regulation and behavior
- ❑ Populations and ecosystems
- ❑ Diversity and adaptations of organisms

History and Nature of Science -CONTENT STANDARD G:
As a result of activities in grades 5-8, all students should develop understanding of

- ❑ Science as a human endeavor
- ❑ Nature of science

Alien Seed Cycle Worksheet

Name _____ Date_____

Fill in the missing information by using the Chart of Seed Production and Germination and choose an alien species to use for your calculations.

Alien Species _____

# of seeds _____ (choose a single number)

Germination Rate _____

Seedling Survival _____

Complete the seed cycle for your alien and answer the following questions. What will be the number of plants and the number of seeds that will be in the seedbank after three years if 100 seeds were dropped by humans into an area?

If 100 were spread accidentally by humans to form a weedy seedbank, ___% of them will germinate and ___% stay in the seedbank.

100 X ____% germination = _____ This is the amount of seeds that will become seedlings.
100 X ___ % not germinated = ___ the Seedbank for the 1st year.
If ___% of those new seedlings will survive and mature into adult plants, then ____number of seedlings X ___% survival = ____ amount of adult plants for the 1st year.
Those _____ adult plants will produce _____ seeds each.
These _____ seeds from the adult plants are added to the _____seeds already in the seedbank = _____, Next years seedbank.

To determine the second year:
Take ____% of the seedbank and they will germinate into seedlings.
____Seedbank total X ___% = _____ This is the amount of seeds that will become seedlings.
____ Seedbank total X ___ % = _____ the percentage of the Seedbank that does not germinate.
If ___% of those seedlings will survive and mature into adult plants, then ____Number of seedlings X ___% survival = _____ amount of adult plants for the 2nd year.
Those _____ adult plants will produce _____ seeds each.
These _____ seeds from the adult plants are added to the _____seeds already in the seedbank = _____, Next years seedbank.

To see how the population will grow in the third year:
Take ____% of the seedbank and they will germinate into seedlings.
____Seedbank total X ___% = _____ This is the amount of seeds that will become seedlings.
____ Seedbank total X ___ % = _____ the percentage of the Seedbank that does not germinate.
If ___% of those seedlings will survive and mature into adult plants, then
____Number of seedlings X ___% survival = _____ amount of adult plants for the 2nd year.
Those _____ adult plants will produce _____ seeds each.
These _____ seeds from the adult plants are added to the _____seeds already in the seedbank = _____, Next years seedbank.

If you finish early and the teacher allows you the time, calculate the fourth year!

Fill in the table below and graph the population explosion of your alien.

Year	Plants	Seed Produced	Seedbank
0	0	0	100
1			
2			
3			
4			

Why is this called a population explosion?

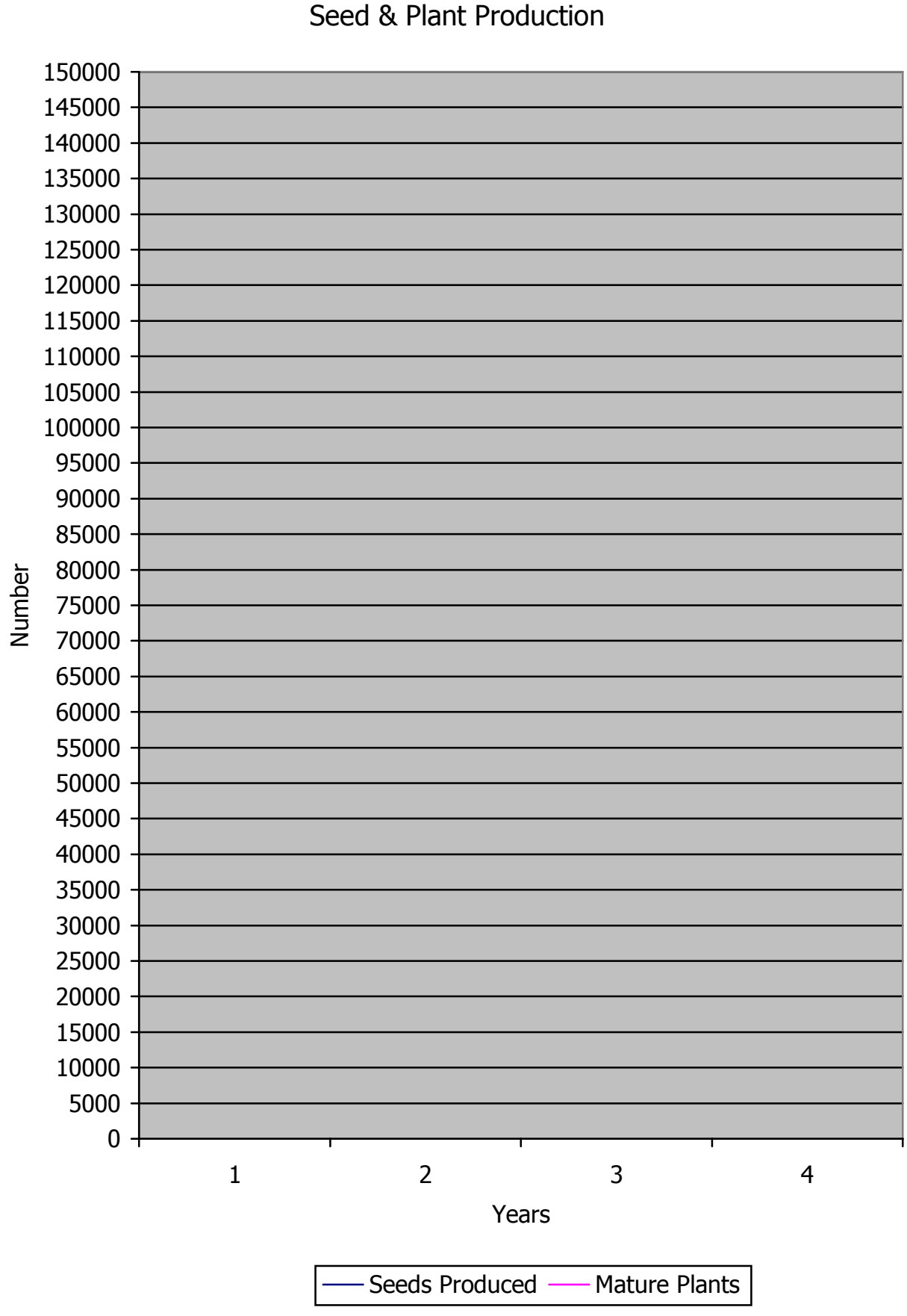
What do you think will happen to the native plants if this weed population explosion continues?

What natural and human barriers prevent populations of plants and animals from growing without limit?

Natural Barriers:

Human Barriers:

Graph the number of seeds and plants that are produced for each of the 3 years on the following page or create your own graph. Use different colors for the two graph lines you create.



Created by Mark Goddard for *Aliens In Your Neighborhood* - 2003

Teacher Information sheet

Seed Production & Survival*

Alien Species	# of Seeds	Survival (yrs)	Germination Rate (%)	Seedling Survival (%)
Canada thistle [a] **Cirsium arvense**	0-40,000	1-22	90	5
Field bindweed [b] **Convolvulus arvensis**	2-4 (per flowerhead)	30-50	90	90
Purple loosestrife [c] **Lythrum salicaria**	100,000-2.5mill	2-3	98	10-20
Spotted knapweed [d] **Centaurea maculosa**	65-25,000	5	90	45-88
Yellow starthistle [e] **Centaurea solstitialis**	30-150,000	10	90-100	50
Cheatgrass [f] **Bromus tectorum**	25-5,000	2-3	95	95

*The numbers used in the chart above are not intended to be representative of all plants in all conditions, though unlike some invasive weed education activities, they do reflect accurate ranges. It may be appropriate to tell your students that purple loosestrife produces 2.5 million seeds, but they should understand that in some situations a plant might only produce a few hundred (in two separate weed education curricula both knapweed and starthistle are represented as *each* producing 1000 seeds/plant and *both* species having a 4% survival rate, without any discussion of more realistic ranges based upon environmental conditions and patterns). Seed production, germination rates and survival will fluctuate widely depending upon the state where the plants are found, the habitats it has invaded, seasonal weather patterns, soil and nutrient conditions, temperature and humidity, depth of seed in the soil, competition, and many other localized factors. Numbers were drawn from the available research on the botanical and ecological characteristics for the species, synthesized in the reports available at the website listed below. For the purpose of the *Aliens In Your Neighborhood* activities, and to illustrate the power of exponential growth, it is suggested that students use a range of numbers for each species when doing the *Population Explosion* activity. Advanced students may want to investigate localized conditions affecting seed production and germination rates.

Additional plant facts and notes:

a – highly dependent on pollination between male and female plants (primarily by bees) and on very specific local environmental conditions.

b – plants produce long stems (20-200 cm) with several flowers per stem, and can successfully reproduce from it's extensive rhizomes (roots may penetrate the soil to a depth of 20'). Seeds can remain viable after passing through animal digestive tracts.

c – Seeds can germinate even when saturated or in soil that is under water. Seeds can be transported in fur of mammals, plumage of waterfowl, mud attached to footgear, vehicle treads or cooling systems of outboard motors, dispersed by birds after ingestion, and by wind and water. The low seedling survival rate should not be taken lightly considering the extremely high number of seedlings that would be present after a 98% germination rate… they would in effect, be their own competitor.

d – Individual plants can live for nine years. Because of the sheer number of seeds, about 0.1% of the seed produced under certain conditions would be needed to maintain the size of the stands (the same figure can hold true for purple loosestrife). Allelopathy and colonization of spotted knapweed roots by arbuscular mycorrhizal fungi, may contribute to its competitive dominance over native grasses.

e – An interesting adaptation is to have hairs and waxy coating on mature yellow starthistle leaves reflect light, thus reducing the heat load and transpiration demand, while winged stems also dissipate heat. Tap roots up to a meter deep also help conserve and find water in direct sun habitat. Long-distance dispersal of yellow starthistle seed is often directly related to human activities and occurs by movement of livestock, vehicles, equipment, and contaminated hay and crop seed [32,35]. Birds such as ring-necked pheasants, California quail, house finches, and American goldfinches feed heavily on yellow starthistle seeds.

f – Cheatgrass reproduces only by seed and, unlike the other species in this list, is an annual. Have students explore the relationship between an annual plant and seed production and why this particular plant is often referred to as a "living wildfire." See http://www.fs.fed.us/database/feis/plants/graminoid/brotec/botanical_and_ecological_characteristics.html for a lengthy description of the range of adaptations and dispersal modes.

Information from various research papers cited for each individual plant at:

U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2003, June). Fire Effects Information System (FEIS), [Online]. Available: http://www.fs.fed.us/database/feis/ [June 9, 2003].

Students interested in additional information can access this site, click on the Invasive Weeds Plants List, and scroll through an extensive list of alien plant species for specific botanical information.

Questions on student Alien Seed Cycle Worksheet:

Why is this called a population explosion?

The plant population is increasing at a rate faster then it would under normal circumstances of competition and other natural barriers that were most likely in place in the plant's native habitat/

What do you think will happen to the native plants if this weed population explosion continues?

Native plants will most likely be suppressed due to loss of water and nutrient resources, shading, allelopathic effects, herbivory and other impacts of severe competition from the large numbers of invasive plants.

What natural and human barriers prevent populations of plants and animals from growing without limit?

Natural barriers (disease, predators, fire, insects)
Human barriers (herbicides, collecting, habitat destruction… see Alien Control Unit).

Chart of Seed Production and Germination

Alien Species	# of Seeds	Survival (yrs)	Germination Rate (%)	Seedling Survival (%)
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Notes: